

IMPROVED LINEAR ION TRAP*

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This paper describes an improvement in the architecture of the physics package used in the Linear Ion Trap (LIT) based frequency standard recently developed at JPL. This new design is based on the observation that ions can be easily moved along the axis of an LIT by applied dc voltages. The optical state selection/interrogation region can be separated from the more critical microwave resonance region where the multiplied output of an LIT is compared to the stable atomic transition.

The separation of these two regions relaxes many of the design constraints of the present units. The microwave resonance region can now be designed with no consideration of optical issues. The linear trap in the microwave region can be enclosed in a simple set of cylindrical magnetic shields and solenoid to supply a very uniform and stable magnetic environment. The volume of the critical shielded region can be reduced by a factor of 100 as the magnetic shields are 10 times smaller in diameter. Since the resonance region requires the most stringent temperature regulation of the entire physics package this reduction in size enables simplification of the thermal shielding.

Similarly, the optical state selection region design is now carried out without worrying about perturbations to the atomic resonance. In practice this means that the optical components are no longer required to be non-magnetic as in the previous design. In the past JPL LIT standard, expensive high vacuum, Copper-Titanium flanged UV transmitting windows were built to satisfy the non-magnetic requirements. These can now be replaced by more readily obtainable S-steel flanged windows. The electron gun assembly, used for ion creation is now far from the resonance region and its assembly and heater current do not influence ion resonance frequency.

Finally, the second order doppler shift from ion motion in the trapping rf field, the largest frequency offset and potential source of instability for clock operation can be greatly reduced in this modified architecture. The magnitude of this frequency shift is proportional to the linear ion density, N/l . An increase in the resonance trap length to about 200 mm would reduce clock sensitivity to ion number variations by a factor of 4 from that in the present system. Since ion number stabilization to the 0.1 % level has been demonstrated for 10^5 frequency standard operation in that system, an ion number induced instability noise floor below 2.5×10^{-6} should be achievable in this modified configuration.

*This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.